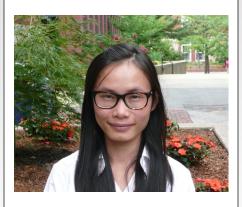# WPI MATHEMATICAL SCIENCES

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PhD Candidate
Mathematical Sciences

Tuesday, April 27, 2021
1:00PM-3:00PM

For Zoom meeting info, please contact
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Carolina State University
Dr. Qingshuo Song, WPI
Dr. Frank Zou, WPI

PhD Dissertation Proposal

Title: Price Impact of VIX Futures and Two Order Book Mean-Field Games

Abstract: This Ph.D. thesis deals with the price impact in the VIX futures market from a statistical and mathematical perspective. The CBOE volatility index, VIX, is known by investors as the fear index. It was introduced to measure the investors' view on the future expected volatility of the S&P 500 stock index. Investors cannot trade the VIX index directly; however, one can trade VIX futures, which gauge the market's expectation of the 30-day implied volatility. Market volatility spiked on February 8, 2018, drawing wide attention to volatility-based products. On that day, the VIX went up more than 100% in intraday trading. The XIV, one of the VIX-based exchange-traded products (ETPs), dropped more than 80%, triggering an "acceleration event." As a consequence, the XIV issuer had to terminate this product. One of the factors contributing to this event was the architecture of the ETPs written on VIX: a daily contracts rolling where the short-term (mid-term) ETPs roll every day to maintain a weighted average of one month (five months) to expiration. Therefore, a large number of shares is expected to be acquired and liquidated every day before the market closes.

We study the effect of VIX ETPs on the price of VIX futures by investigating the impact curves at different times of the trading day. We find that the impact curve corresponding to the time before market close is the lowest. Our empirical results show that impact curves exhibit a power-law. This is theoretically justified by using dimensional analysis to show that if the immediate price impact is a function of the trade size, it is given by a power function.

We propose a mean-field game framework for the VIX futures market to complement our empirical study, where traders can trade in a regular order book (ROB) and a trade-at-settlement order book (TASOB). We assume that there are many high frequency traders (HFTs) in the market, and they trade in both order books. We investigate the case where the number of HFTs tends to infinity. While transactions in ROB suffer from a temporary price impact, transactions in TASOB do not, but they trade at an unknown price, the daily settlement price that is only determined at the end of the trading day. We use the extended mean-field games approach, interactions between agents through controls instead of states, to solve an optimal trading problem in two order books. We plan to extend our framework to include ETFs/ETNs to act as a major player in the VIX futures market.